PB86-195252

Screening Polynuclear Aromatic Pollutants in Ambient and Indoor Air by Synchronous Luminescence

Oak Ridge National Lab., TN

Prepared for

Environmental Monitoring Systems Lab.
Research Triangle Park, NC

May 86

U.S. Department of Commerce
National Technical Information Service
NTIS

PB86-195252

EPA/600/D-86/102
May 1986

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by

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Interagency Agreement
DW 89930725

EPA Project Officer
N. K. Wilson

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U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA/600/D-86/102		

4. TITLE AND SUBTITLE
SCREENING POLYNUCLEAR AROMATIC POLLUTANTS IN AMBIENT AND INDOOR AIR BY SYNCHRONOUS LUMINESCENCE

5. REPORT DATE
May 1986

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
T. Vo-Dinh, G. H. Miller and N. K. Wilson

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.
IAG DW89930725

12. SPONSORING AGENCY NAME AND ADDRESS
U.S. Environmental Protection Agency
Environmental Monitoring Systems Laboratory
Methods Development & Analysis Division, MDB/AMS
Research Triangle Park, NC 27711

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE
EPA/600/09

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Polynuclear aromatic (PNA) pollutants are of concern in indoor and outdoor air monitoring because many PNAs are carcinogenic in laboratory animal biotesting. For comprehensive exposure studies, which usually involve large population distributions and extended assessment periods (several years), there is an urgent need for practical and cost-effective analytical tools to screen large numbers of samples.

Synchronous luminescence (SL) has recently been developed as a simple and cost-effective analytical method to be used in an integrated screening procedure for monitoring complex multi-media samples. In conventional luminescence spectroscopy, either the excitation (λex) or the emission wavelength (λem) remains fixed. With the SL technique, the emission signal is recorded while λex and λem are scanned simultaneously using a constant interval, $\Delta\lambda$, between the two. Simplicity of the analytical procedures and low cost of the instrumentation make SL very suitable as a screening technique.

Screening procedures would be useful in providing information on the presence and distribution profile of selected PNA pollutants in ambient air samples and thereby alleviate the need to conduct costly analyses. The sensitivity, selectivity, and cost-effectiveness of the SL screening method for monitoring PNA pollutants in indoor and outdoor environments will be discussed.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	8
	20. SECURITY CLASS *(This page)*	22. PRICE
	UNCLASSIFIED	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

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INTRODUCTION

The characterization of polynuclear aromatic (PNA) compounds in ambient and indoor environments is of great importance because many of these compounds are known to be converted by metabolic activation to ultimate carcinogens[1] and could pose serious potential human health hazards. Health assessment studies of the exposure of any given population group to PNA pollutants could be costly because these studies require extensive and long-term monitoring and analysis programs involving large numbers of samples and the use of sophisticated analytical techniques, such as high-performance liquid chromatography (HPLC) and gas-chromatography/mass spectrometry (GC/MS). In many monitoring situations, the determination of all individual PNAs may be unnecessary, and a screening phase to identify critical problem areas can reduce the cost of monitoring programs and allow more practical, cost-effective, and feasible design of comprehensive health assessment studies.

This paper discusses the results of a field study designed to evaluate a screening procedure based on synchronous luminescence (SL), for ranking air samples according to their total PNA content [2,3]. The SL technique can be used not only for chemical detection, but also for monitoring biological markers, such as carcinogen-DNA adducts in human biological fluids due to exposure to PNA pollutants[4-6].

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under IAG DW 89930725 with the U.S. Department of Energy. It has been subjected to Agency review and approved for publication.

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This project was conducted by Oak Ridge National Laboratory (ORNL) in conjunction with a pilot sampling and analysis field study, which was used as the basis for sampling. The sampling field study was performed by Battelle's Columbus Laboratories (BCL)[7], and involved eight residences and two background homes located in Columbus, Ohio. Air samples were collected on quartz fiber filters followed by polyurethane foam (PUF) cartridges. These air samples, collected by active medium-volume samplers, were extracted by BCL, analyzed by GC/MS and concurrently sent to ORNL for SL screening.

EXPERIMENTAL

Synchronous Luminescence Screening

The screening procedure evaluated in this field study is based on the synchronous luminescence (SL) technique. In conventional luminescence spectroscopy, only one of the two spectral wavelengths, λem (emission) or λex (excitation), is scanned while the other remains fixed. For complex samples, the resulting spectra obtained with this conventional procedure are often poorly resolved and featureless because of spectra overlap between the emissions from individual components. However, by scanning both λem and λex synchronously with a constant interval $\Delta\lambda$ between the two wavelengths ($\lambda em - \lambda ex = \Delta\lambda$, usually 3-5 nm for PNAs), the luminescence spectrum becomes more resolved, with sharp peaks that are more readily identified[8-10].

Analytical Protocol

The three major steps involved in the protocol are: (a) serial dilution of sample extracts, (b) SL measurement, and (c) ranking the samples.

Serial Dilution. Upon receipt, all air particulate sample extracts (in methylene chloride) were further diluted in ethanol without sample cleaning or fractionation. Three serial dilutions were made per sample.

SL Measurements. In this field study, the synchronous scanning technique greatly enhanced the resolution of fluorescence spectra and was mainly applied to fluorescence measurements. The diluted solutions of each sample were introduced into standard 1 x 1 cm quartz cells for synchronous fluorescence scanning. The SL profiles were recorded from 260 to 500 nm using $\Delta\lambda$ = 4 nm.

RESULTS AND DISCUSSION

The advantage of a screening technique, such as SL, is the ability to rank several samples with regard to relative PNA content with very little sample preparation and at a low cost. This can decrease the number of detailed analyses by GC/MS or HPLC: selection can be made for analysis of those samples containing the highest levels of PNAs. It is also possible using SL to distinguish between relative amounts of PNA compounds having differing molecular weights.

Figure 1 shows examples representing three types of residences with different environmental conditions monitored in this study. Figures 1a,

1b, and 1c correspond to indoor air samples (8-hour, PUF + Filter extracts) of a gas-heated home with smokers, a gas-heated home with a fireplace, and a home with only electric heat. A rapid examination of the intensity distribution of the three SL profiles qualitatively provides several conclusions. As a general rule, the larger the number of rings an aromatic compound contains, the longer the wavelength at which its emission band occurs[8]. An SL band below 300 nm region shows the presence of a monocyclic species. An SL band in the 300 to 380 nm region indicates the presence of compounds containing two or three benzene rings. An SL band above 380 nm shows the presence of compounds containing four or more benzene rings. For example, in Figure 1a the SL peaks at 286 and 308 nm are indicative of monocyclic compounds in the house with smokers. The SL band at about 330 nm is representative of compounds with two benzene rings. The clusters of overlapping peaks from 350 to 500 nm spectral region reflect the abundant presence of PNA species with three to seven benzene rings.

Figure 2 shows an example of the comparative SL emission at 362 nm for homes with smokers vs. homes without smokers. These results indicate a significantly higher PNA content due to the presence of cigarette smokers in the home. The higher PNA levels due to smoking activities and reflected in the overall SL ranking were found in all indoor sampling locations. Outdoor samples show lower PNA content than indoor samples. Detailed discussion of the effects of other factors, including gas appliances, fireplaces, electric heaters, are presented elsewhere[11].

The air sample extracts screened by SL have been also independently analyzed by Battelle Laboratories using GC/MS. The GC/MS analysis provided the content of fifteen PNA compounds including quinoline, isoquinoline, phenanthrene, anthracene, fluoranthene, cyclopenta(c,d)pyrene, benz(a)anthracene, chrysene, benzofluoranthenes, benzo(e)pyrene, benzo(a)pyrene, indeno(1,2,3-c,d) pyrene, benzo(g,h,i)perylene, and coronene[7]. The correlation coefficient for the comparison between the SL ranking data and the GC/MS results is 0.72. Considering the simplicity and rapidity of the SL procedure, this correlation is satisfactory for a screening phase.

The results obtained in this study demonstrate the sensitivity and usefulness of the SL screening procedure for monitoring indoor air pollution. The concentrations of PNAs detected by GC/MS are in good agreement with the results predicted by the SL screening measurements. Although the usefulness of analytical techniques such as GC/MS and HPLC is well established for detailed characterization of individual compounds, it is not cost-effective to apply these tools systematically to all samples, especially when many of the samples contain low levels of PNAs or similar PNA constituents that can be predicted in a screening phase. Before selection of which group of samples is to be analyzed in detail or which analytical techniques are to be utilized, it is desirable to have some screening procedure to prioritize samples. Such a screening step may obviate the need to perform unnecessary and costly detailed analyses and will lower the cost of health effect assessment studies.

ACKNOWLEDGEMENT

This research is jointly sponsored by the U.S. Environmental Protection Agency under Interagency Agreement No. DW 89930725/DOE-40-1445-84/1 and the Office of Health and Environmental Research, U.S. Department of Energy under contract DE-AC05-840R21400 with Martin Marietta Energy Systems, Inc.

REFERENCES

1. G. Grimmer, (Ed.), Environmental Carcinogens: Polycyclic Aromatic Hydrocarbons, CRC Press, Boca Raton, Florida (1983).

2. T. Vo-Dinh, T. J. Bruewer, G. C. Colovos, T. J. Wagner, and R. H. Jungers, Environ. Technolog., 18, 477 (1984).

3. D. W. Abbott and T. Vo-Dinh, Environ. Internat. 10, 299 (1984).

4. R. O. Rahn, S. S. Chang, J. M. Holland, T. J. Stephens, and L. H. Smith, J. Bichem. Biophys. Methods, 3, 285 (1980).

5. K. Vahakangas, A. Haugen, and C. C. Harris, Carcinogenesis, 6, 1109 (1985).

6. M. Uziel, G. H. Miller, R. L. Moody, and T. Vo-Dinh, Anal. Lett., 18 (B15), 1821 (1985).

7. C. C. Chuang, G. A. Mack, J. R. Koetz, and B. A. Peterson, "Pilot Study of Sampling and Analysis for Polynuclear Aromatic Compounds in Microenvironments," Battelle Laboratories, Columbus, Ohio (1985).

8. T. Vo-Dinh, Anal. Chem., 50, 396 (1978).

9. T. Vo-Dinh, Appl. Spectrosc., 36, 576 (1982).

10. T. Vo-Dinh, R. B. Gammage, and P. R. Martinez, Anal. Chem., 53, 253 (1981).

11. T. Vo-Dinh, G. H. Miller, D. W. Abbott, and K. R. Reitz, "Evaluation of Screening Methodology for Polynuclear Aromatic Air Pollutants in Residential Environments," Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831.

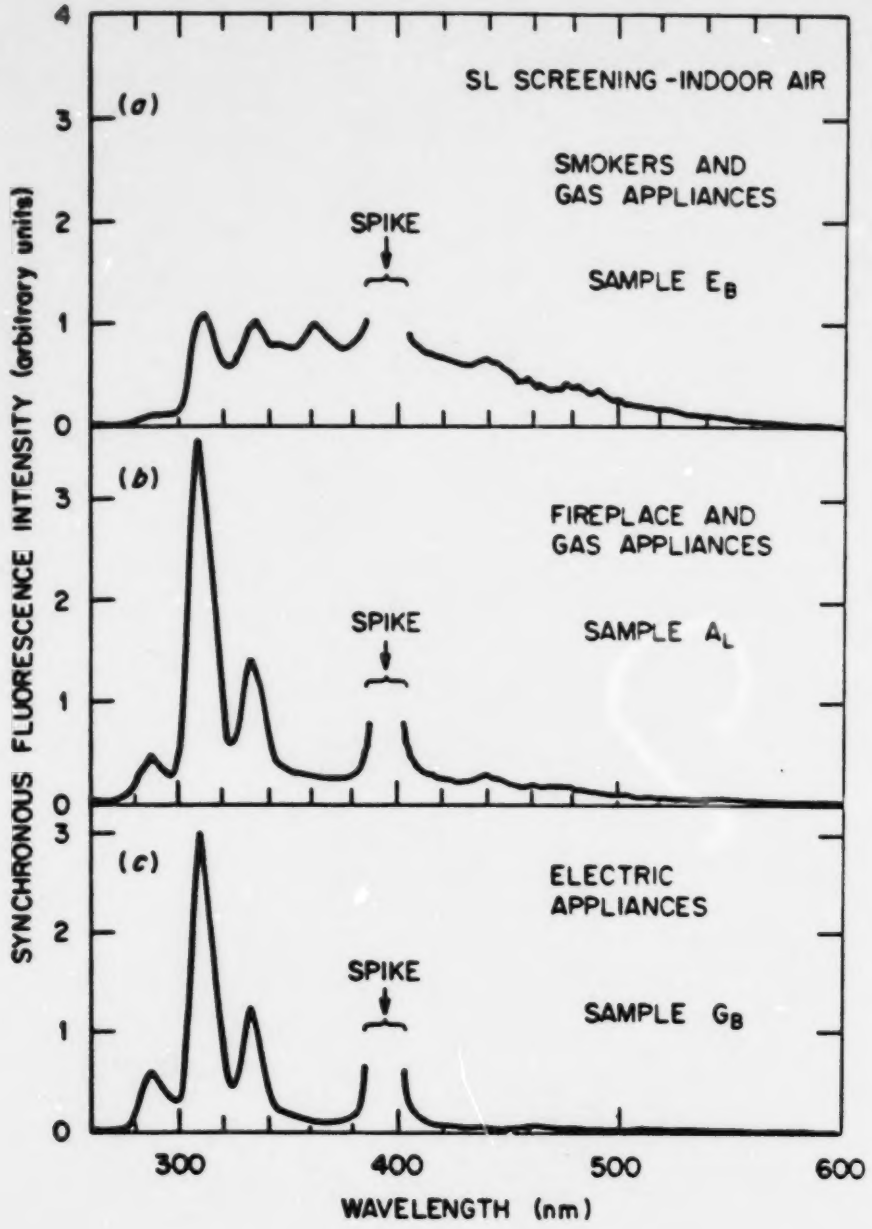

Figure 1: Examples of SL Spectral Profiles of Indoor Air Sample Extracts.

a) Gas heated home with smokers (sample E_b)
b) Gas heated home with fireplace (sample A_1)
c) Electric heated home (sample G_b)

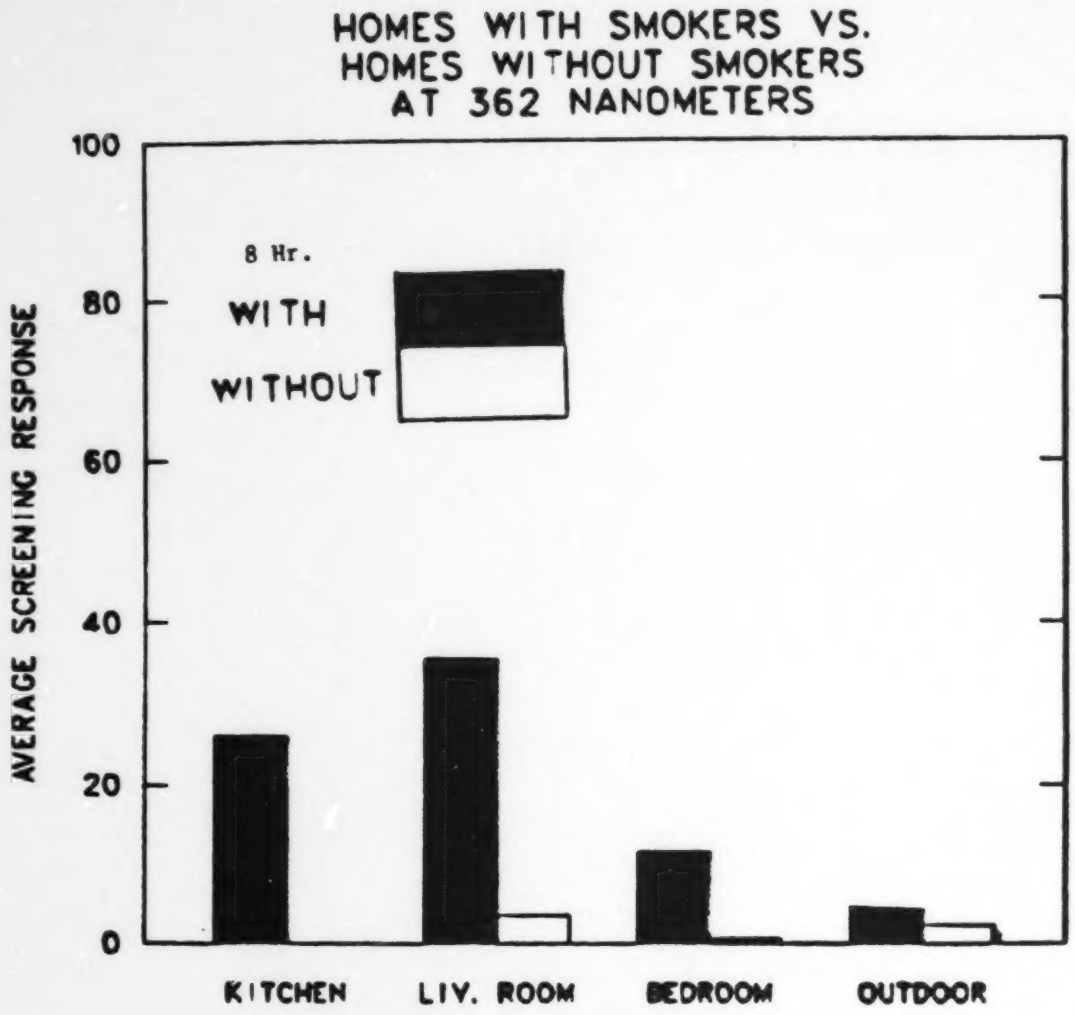

Figure 2: Effect of Cigarette Smoking on the SL Emission Peak at 362 nm.